Low Temperature Testing of the LTC1419 A/D Converter

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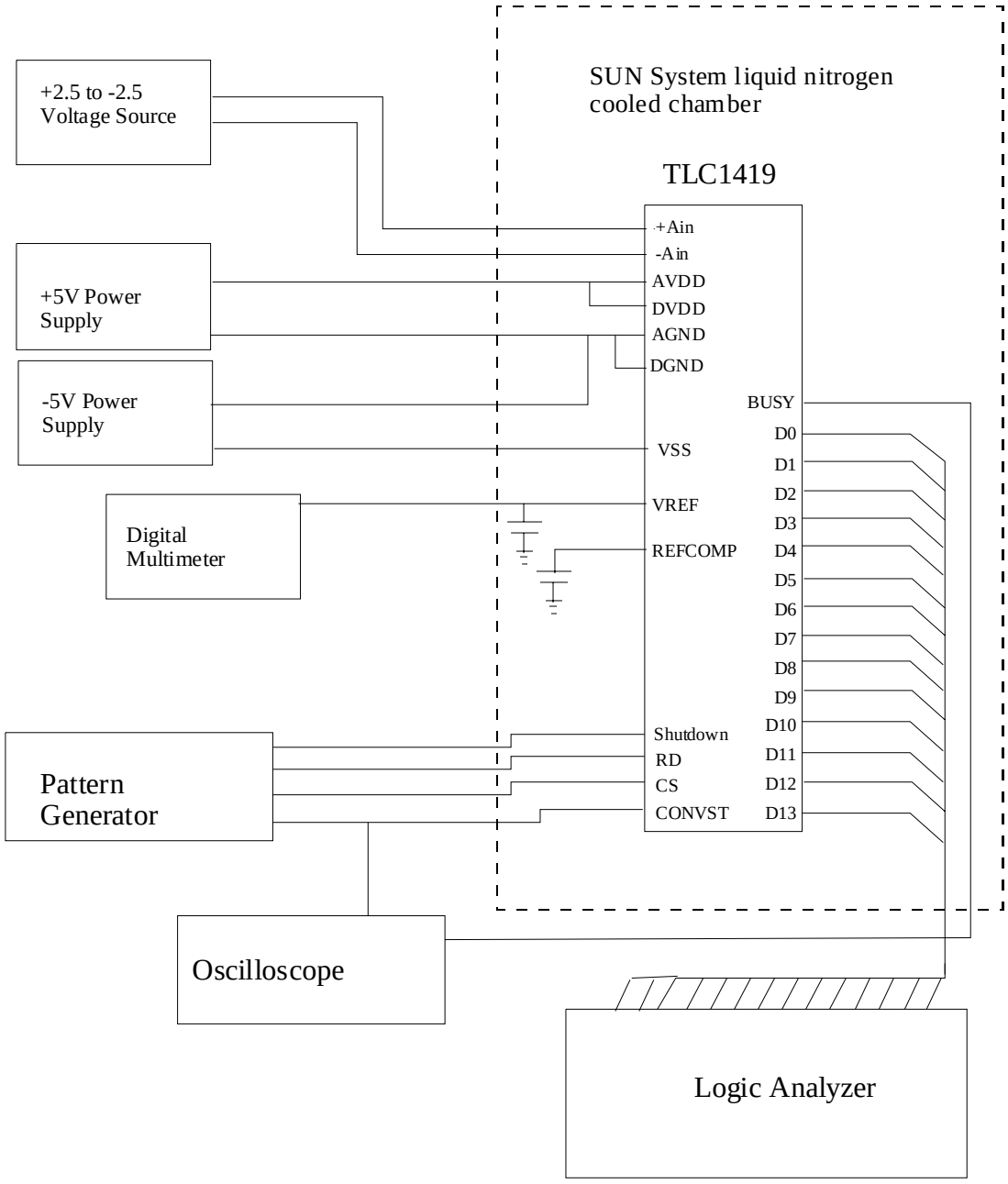
Functional testing of the LTC1419 A/D Converter was performed over the temperature range of 25°C to -190°C. The Linear Technology LTC1419 (1419) is a 14-bit, 800ksps sampling A/D converter. Samples of two different grades of the LTC1419 devices were obtained both in the (SW) package. The first was the commercial (C) grade, with a manufacturer's specified operating temperature range of 0°C to 70°C. The second was the (AI) version (better linearity) in the industrial grade, with a manufacturer's specified operating temperature range of -40°C to 85°C. A test circuit was constructed such that a logic analyzer and pattern generator could be interfaced to the 1419. Figure 1 shows the test setup. The test setup was configured such that the 1419 was operated in mode 1a as defined in the Linear Technology device data sheet. In this mode, the /CS and /RD pins are tied low, thus selecting the 1419 and always enabling the data outputs. A falling edge on the /CONVST pin will start a conversion. A rising edge on the /BUSY pin signals that the output data can be latched.

Test Results 1419C (Commercial Grade)

The 1419 device can be operated using its own 2.5V internal reference or by an external user specified reference (by overdriving the Vref pin). The internal reference was selected for initial testing of the 1419 device. Testing of the 1419C was initiated at room temperature (22°C). Testing involved recording the /CONVST and /BUSY signals on a digital oscilloscope, monitoring the reference voltage on a digital multimeter, and recording the data outputs with a logic analyzer for several dc input values to the 1419C analog inputs. The dc inputs spanned the (+2.5V to -2.5V) range of the 1419C with a 2.5V reference. The analog input range is dependent on the reference voltage level. Table 1 shows the results of testing the 1419C with the internal reference selected. The logic analyzer recorded the digital output of the 1419C and displayed the corresponding decimal equivalent. This decimal equivalent when multiplied by the equivalent volts/bit gives the measured voltage of the data output. As seen in Table 1, output data was obtained down to -50°C. As the temperature was decreased to -75°C the internal reference voltage dropped from 2.492 volts to 0.906 volts (somewhere around -60°C). At this point, the device has become effectively non-functional, that is there is no reference to measure the inputs by. At this point, a 2.5 volt external reference was applied to the Vref input. Surprisingly, the 2.5V external reference did not overdrive the internal reference at temperatures below -60°C. However, if the external reference was reduced to 1.25 Volts (the minimum specified external reference voltage), the 1419C would operate. Table 2 and 3 show the results of the 1419C testing with a 1.25 volt external reference. With the 1.25V external reference the 1419C device worked quite well down to -190°C. However, some noticeable increase in measured offset between the input and measured output voltage was observed (Table 3).

FIGURE 1. TEST SETUP FOR LTC1419



* Figure 1 does not show bypass capacitors and ground plane connections.

Table 1. Measured Output Voltage vs. Analog Input Voltage at various temperatures (1419C with 2.5V internal reference).

	Measured output (V)				
Ain (V)	22°C	0°C	-25°C	-50°C	-60°C
2.5	2.496	2.495	2.495	2.492	
2	2.003	2.003	2.003	2.000	
1.5	1.502	1.501	1.504	1.502	
1	1.002	1.003	1.003	1.002	
0	0.001	0.001	0.001	0.001	
-1	-1.001	-1.001	-1.001	-1.000	
-1.5	-1.503	-1.502	-1.504	-1.502	
-2	-2.002	-2.001	-1.996	-1.995	
-2.5	-2.496	-2.495	-2.495	-2.492	
Vref	**2.496**	**2.495**	**2.495**	**2.492**	**0.906**

Table 2. Measured Output Voltage vs. Analog Input Voltage at various temperatures (1419 with 1.25V external reference).

	Measured Output (V)					
Analog Input (V)	-75°C	-100°C	-125°C	-150°C	-175°C	-190°C
1	0.9953	0.9953	0.9950	0.9829	0.9806	0.9760
0.5	0.4967	0.4964	0.4926	0.4917	0.4877	0.4869
0	0.0001	0	0	0	0	0
-0.5	-0.5001	-0.5003	-0.4975	-0.4950	-0.4918	-0.4883
-1	-0.9976	-0.9970	-0.9927	-0.9904	-0.9821	-0.9772

Table 3. Measured Offset with 1.25V external reference (1419C).

	Measured Offset (Analog Input-Measured Output) (V)					
Analog Input (V)	-75°C	-100°C	-125°C	-150°C	-175°C	-190°C
1	0.0047	0.0047	0.0050	0.0171	0.0194	0.0240
0.5	0.0033	0.0036	0.0074	0.0083	0.0123	0.0130
0	-0.0002	0	0	0	0	0
-0.5	0.0001	0.0003	-0.0025	-0.0050	-0.0082	-0.0117
-1	-0.0024	-0.0030	-0.0073	-0.0096	-0.0179	-0.0228

Figures 2 shows the /CONVST input signal and the 1419C /BUSY output signal at 25°C and –175°C, respectively. Figure 2 also shows the conversion time (t_{conv}) as defined by the manufacturer's data sheet. The manufacturer's data sheet specifies the typical and maximum conversion times to be 950ns and 1150ns, respectively. Table 4 shows the measured conversion times for the 1419C from 25°C to -190°C.

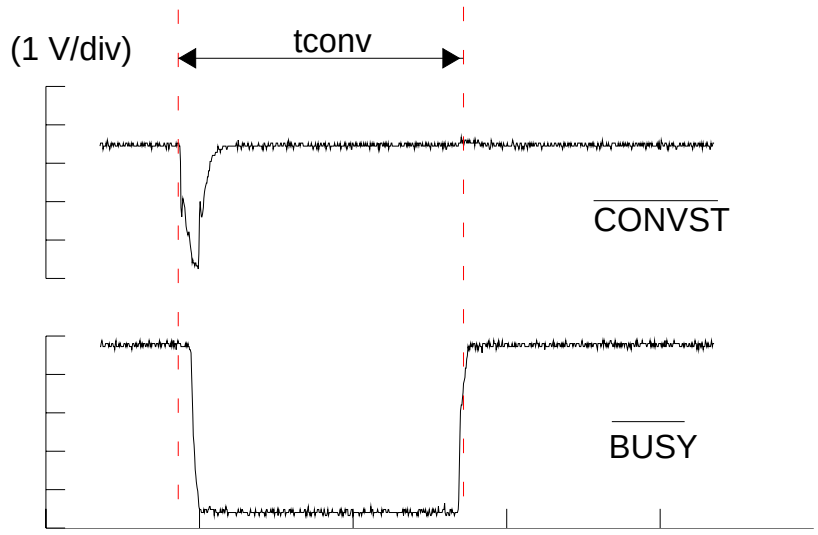


Figure 2. The /CONVST input signal and the /BUSY output signal at 25°C and –175°C, respectively.

Table 4. LTC1419 Conversion Time vs Temperature

Temperature	22°C	0°C	-25°C	-50°C	-75°C	-100°C	-125°C	-150°C	-175°C	-190°C
t_{conv} (ns)	920	920	920	880	872	856	840	840	840	840

Test Results LTC1419AISW (Industrial Grade)

The internal reference was selected for initial testing of the 1419AI device. Testing of the 1419AI was initiated at room temperature (22°C) with the same setup used previously. Table 5 and 6 show the results of testing the 1419AI with the internal reference selected. As seen in Table 5, output data was obtained down to -50°C. As the temperature was decreased to -75°C the reference voltage dropped from 2.49 volts to 0.937 volts (somewhere around -72°C). This is the same behavior observed for the commercial grade 1419. At this point, the device has become effectively non-functional, that is there is no reference to measure the inputs by. At this point, a 2.5 volt external reference was applied to the Vref input. As before, the 2.5V external reference did not overdrive the internal reference at temperatures below -60°C. However, if the external reference was reduced to 1.25 Volts (the minimum specified external reference voltage), the 1419 would operate. We were able to increase the external reference voltage to 1.6V and still have the 1419AI operate. Table 7 and 8 show the results of the 1419AI testing with a 1.6 volt external reference. With the 1.6V external reference the 1419AI device worked quite well down to -190°C. However, some noticeable increase in measured offset between the input and measured output voltage was observed (Table 8).

Table 5. Measured Output Voltage vs. Analog Input Voltage at various temperatures (LTC1419AISW with 2.5V internal reference).

	Measured output (V)					
Analog Input (V)	22°C	0°C	-25°C	-50°C	-72°C	**25°C
2.5	2.498	2.496	2.493	2.489		2.497
2	1.999	1.998	1.994	1.993		1.997
1.5	1.500	1.499	1.497	1.496		1.497
1	1.000	0.999	0.998	0.997		1.000
0	0.001	0.001	-0.000	0		0
-1	-1.000	-1.000	-1.000	-0.997		-1.000
-1.5	-1.5	-1.498	-1.502	-1.496		-1.499
-2	-1.998	-1.997	-1.996	-1.991		-1.997
-2.5	-2.498	-2.496	-2.493	-2.49		-2.497
Vref	**2.498**	**2.496**	**2.493**	**2.49**	**0.937**	**2.497**

Table 6. Measured Offset (LTC1419AISW with 2.5V internal reference).

	Measured Offset (Analog Input-Measured Output) (V)				
Analog Input (V)	22°C	0°C	-25°C	-50°C	**25°C
2.5	-0.002	-0.004	-0.007	-0.011	-0.003
2	-0.001	-0.002	-0.006	-0.007	-0.003
1.5	0.000	-0.001	-0.003	-0.004	-0.003
1	0.000	-0.001	-0.002	-0.003	-0.000
0	0.001	0.001	-0.000	0	0
-1	-0.000	0.001	-0.000	0.003	0.000
-1.5	0.000	0.002	-0.002	0.004	0.001
-2	0.002	0.003	0.004	0.009	0.003
-2.5	0.002	0.004	0.007	0.01	0.003

Table 7. Measured Output Voltage vs. Analog Input Voltage at various temperatures (LTC1419AISW with 1.6V external reference).

	Measured Output (V)						
Analog Input (V)	-75°C 1.25V ref	-100°C 1.6V ref	-125°C 1.6V ref	-150° 1.6V ref	-175°C 1.6V ref	-190°C 1.6V ref	**25°C 1.6V ref
1.6		1.562	1.556	1.556	1.553	1.553	1.569
1.5		1.469	1.456	1.456	1.455	1.455	1.481
1.25	1.221	1.231	1.219	1.212	1.211	1.211	1.235
1.0	0.981	0.980	0.969	0.969	0.967	0.967	0.987
0	-0.002	-0.000	0	0	-1.6	0	-0.002
-1.0	-0.985	-0.985	-0.981	-0.975	-0.988	-0.988	-0.987
-1.25	-1.230	-1.23	-1.225	-1.224	-1.225	-1.225	-1.237
-1.5		-1.478	-1.474	-1.472	-1.462	-1.481	-1.486
-1.6		-1.581	-1.574	-1.567	-1.581	-1.581	-1.586

Table 8. Measured Offset with 1.6V external reference (LTC1419AISW).

	Measured Offset (Analog Input-Measured Output) (V)						
Ain (V)	-75°C	-100°C	-125°C	-150°C	-175°C	-190°C	**25°C
1.6		-0.038	-0.044	-0.044	-0.047	-0.047	-0.031
1.5		-0.031	-0.044	-0.044	-0.045	-0.045	-0.019
1.25	-0.029	-0.019	-0.031	-0.038	-0.039	-0.039	-0.015
1	-0.019	-0.020	-0.031	-0.031	-0.033	-0.033	-0.013
0	-0.002	-0.000	0	0	-1.600	0	-0.002
-1	0.015	0.016	0.019	0.025	0.0124	0.012	0.013
-1.25	0.020	0.020	0.025	0.026	0.025	0.025	0.013
-1.5		0.022	0.026	0.028	0.038	0.019	0.014
-1.6		0.019	0.026	0.033	0.019	0.019	0.014